

**METHOD AND APPARATUS FOR**  
**PROVIDING LOW COST FORCE FEEDBACK AND**  
**MECHANICAL I/O FOR COMPUTER SYSTEMS**

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**ABSTRACT OF THE DISCLOSURE**

A method and apparatus for interfacing the motion of a user-manipulable object with an electrical or computer system includes a user object physically contacted by a user. A gimbal mechanism is coupled to the user object, such as a joystick or a medical tool, and provides at least two degrees of freedom to the user object. The gimbal mechanism preferably includes multiple members, at least two of which are formed as a unitary member which provides flex between the selected members. An actuator applies a force along a degree of freedom to the user object in response to electrical signals produced by the computer system. A sensor detects a position of the user object along the degree of freedom and outputs sensor signals to the computer system. Another embodiment includes a host computer system and a local microprocessor, separate from the host computer, for communicating with the host computer and controlling the forces output by the actuators according to a processor subroutine selected in accordance with a host command, sensor signals, and timing information. Another embodiment of the interface apparatus uses voice coil actuators that produce forces in either linear or rotary degrees of freedom using currents applied in a magnetic fields. A friction drive mechanism of the present invention can be coupled between an actuator and a gimbal mechanism. Force from the actuator is transmitted to the gimbal mechanism through frictional contact of members of the friction drive mechanism.